NASA TT F-9594

PROBLEM CONCERNING DISTURBANCES OF THE LOCAL BLOOD CIRCULATION IN MAN UNDER THE INFLUENCE OF PROLONGED TRANSVERSE ACCELERATIONS

M.D.Yemel'yanov and E.S.Kotova

Translation of "K voprosu o narusheniyakh regionarnogo krovoobrashcheniya u cheloveka pri dlitel'no deystvuyushchikh poperechno napravlennykh uskoreniyakh". Paper presented at the XVI International Astronautical Congress, Athens, September 13 - 18, 1965.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON OCTOBER 1965

XVI INTERNATIONAL ASTRONAUTICAL CONGRESS

Athens, September 13 - 18, 1965

PROBLEM CONCERNING DISTURBANCES OF THE LOCAL BLOOD CIRCULATION IN MAN UNDER THE INFLUENCE OF PROLONGED TRANSVERSE ACCELERATIONS

M.D.Yemel'yanov and E.S.Kotova

(USSR Ministry of Health)

Moscow, 1965

PROBLEM CONCERNING DISTURBANCES OF THE LOCAL BLOOD CIRCULATION IN MAN UNDER THE INFLUENCE OF PROLONGED TRANSVERSE ACCELERATIONS */1

M.D.Yemel'yanov and E.S.Kotova

The tolerance of the human organism for protracted and repeated transverse acceleration is investigated on the basis of changes in the cardiovascular system and specifically the retinal blood supply. Ophthalmodynamometer and campimeter examinations as well as centrifuge tests showed phasic changes in vascular tonus, hyper- and hypotension of local character in the optic artery, and pathological changes in the retino-brachial index. Residual reactions in the form of dilatation of the retinal veins of as much as 50 μ over normal persisted for up to 11 days after the acceleration test.

Author

Numerous studies have been devoted to the problem of the influence of prolonged accelerations on the organism, relative to the conditions of space travel (V.V.Parin, O.G.Gazenko, V.I.Yazdovskiy, V.N.Chernigovskiy, A.S.Barer, G.Müller, 1961, and others).

However, up to now several important problems remain unclarified, such as those of tolerance for repeated accelerations, significance of training, effect of transition from acceleration to weightlessness and vice versa, and others. Quite obviously, this situation is due to the difficulty of simulating conditions of space flight on the ground and to the absence of sufficiently reliable criteria for recognizing the early unfavorable physiological shifts in the human

* Numbers in the margin indicate pagination in the original foreign text.

organism.

In this connection, hemorrhages in the internal organs of animals, which have been described by a number of authors (A.Stole, G.Mosely) particularly indicate the need for caution since such hemorrhages might occur even at moderate acceleration, although never disclosed by ordinary conditions of examination. It is well known that one of the basic physiological factors, limiting the tolerance for accelerations, are changes in the cardiovascular system (D.Ye.Rozenblyum, 1963, V.I.Babushkin et al., 1961, and others). Interference with the supply of blood to brain and eyes is responsible for loss of consciousness and failure of vision.

Under these conditions, a study of the retinal blood supply becomes necessary for understanding the mechanism of local processes in the eye that cause /2 loss of peripheral and central vision, and of the changes in the carotid circulation system (A.Ya.Vilenkina, B.N.Klosovskiy, Bailliart, Weigelin, and many others). These authors assert that the arteries of the retina reflect the changes in the cerebral blood vessels and of the intracranial pressure. In fact, the phylogenetic similarity between eye and brain and the blood vessels of the latter makes it possible to judge the state of cerebral circulation from the retinal circulation. All observed changes reflect intracranial vascular shifts.

Bearing these points in mind, our methodology included ophthalmodynamometry, campimetric examinations of angioscotomas and of the blind spot, as well as the conventional clinical tests on visual acuity, accommodation, etc.

Ophthalmodynamometry is a method which determines in very great detail any alterations of varying etiology in the system of the interior carotid artery. A comparison of the values of the retinal and total arterial pressure permits

estimating the intracranial pressure.

The state of the blood vessels of the conjunctiva of the eyeball, the episclera, and the retina was determined by the aid of color photography.

All these studies were performed in a time sequence beginning with the first minute after the motion of the centrifuge had stopped, continuing during the immediate aftereffects, and ending only after complete restoration of function.

We assume that this group of ophthalmological examination methods would disclose the very first signs of hemodynamic shifts, especially in the system of cerebral circulation, and would provide additional data for judging the dynamics of the trace reactions of the cardiovascular system on acceleration.

Several series of experiments were performed on human subjects. Accelerations of various directions were used, ranging from small values to the extreme limits of tolerance in magnitude and time of action. Particular attention was paid to repeated action.

The studies revealed very regular reactions manifested in phasic changes in vascular tonus, mainly in diastolic pressure and in the diameter of the retinal arteries and veins.

During the immediate aftereffect, we determined hypertension in the optic artery, which was of pronounced regional character and alternated with hypotension. There were pathological changes in the retino-brachial index. There was a clear-cut regularity with increase of qualitative changes under the influence of accelerations up to 14 G. At higher accelerations, individual differences were clearly manifested.

In contrast to the commonly accepted view that all functions are rapidly restored after termination of the acceleration effect, we observed residual re-

actions in the form of dilatation of the retinal veins of as much as 170 μ /3
(the corresponding normal diameter for that age being 125 - 155 μ) which persisted for 5, 8, and 11 days after the experiment.

A very important finding were hemorrhages in the conjunctiva of the lids and eyeball, and in the retina. The dynamic tests revealed a varied genesis of formation. Together with the hemorrhages on the disk of the optic nerve, which sometimes appeared within 12 - 100 min following the acceleration, massive hemorrhages occurred in some subjects 24 - 35 hrs after the experiment, along the main retinal blood vessels.

In 1954, Duane first described the changes in the retinal blood vessels during positive longitudinal accelerations. Duane, E.Lambert, E.Wood and others found that the failure of vision ("blackout") under acceleration was a phenomenon of retinal ischemia. The results of these investigators, however, were apparently based on visual observations during the period of acceleration and the immediate aftereffect.

Our studies permit us to develop and extend the above propositions. In all probability the loss of vision (black screen) occurs earlier than the loss of consciousness only because the retina is a tissue which is extremely sensitive to anoxia. It is very probable that the local hypertension during the immediate aftereffect noted by us is of the nature of a protective adaptive reaction and is a factor of great significance in overcoming the resistance of the collaterals during restoration of the cerebral circulation.

It may also be postulated that the arterial pressure increases on slowing the centrifuge. One of the factors confirming this view is the restoration of the peripheral and central vision, disturbed during the period of the "plateau", already at the beginning or middle of the deceleration.

There can be no doubt that only by profound study of the mechanism of the circulatory reactions will it be possible to solve the problems of establishing rational regimes of preparation and training of space-flight specialists. A study of the recuperative period, after the action of accelerations, will also permit a more correct approach to an evaluation of the shifts that might take place in the human organism under conditions of weightlessness immediately after the spacecraft has passed through the dense layers of the atmosphere.

BIBLIOGRAPHY 4

1. Parin, V.V., Gazenko, O.G., and Yazdovskiy, V.I.: Vestnik Akad. Nauk SSSR, No.4, 1962.
2. Chernigovskiy, V.N.: Zhur. vys. nerv. deyat., 1956.
3. Barer, A.S.: Problems of Astrobiology (Problemy kosmicheskoy biologii). Izd. Akad. Nauk SSSR, Vol.2, 1962.
4. Müller, G.C.: Bio-essey on Technical Human Centrifuges and Physiological Effects of Acceleration. Oxford, London, New York, Paris, 1961.
5. Holl, A.M. and Mosely, I.D.: J. Aviat. Medic., Vol.29, No.3, pp.575 - 586, 1958.
6. Rozenblyum, D.Ye.: Uch. zap. inst. im Krupskoy, Part III, 1963.
7. Isakov, P.K., Babushkin, V.I. et al.: Voyenno-medits. zhur., No.1, 1961.
8. Vilenkina, A.Ya.: In "Collection of Papers, Dedicated to the Memory of M.I.Averbakh" (Sb. rabot, posvyashchennyy pamyati akad. M.I.Averbakh). Moscow-Leningrad, Medgiz, 1948.
9. Klosovskiy, B.N.: Blood Circulation in the Brain (Tsirkulyatsiya krovi v mozgu). Moscow, Medgiz, 1951.
10. Koreysha, L.A.: Second Session of Neurosurgeons (II sessiya neyrokhirurgov),

pp.207 - 219, Moscow, 1935.

11. Bailliart, P.: Annal. d'oculist., No.166, pp.271 - 295, 1928.

12. Weigelin, E.: Am. I. of Ophthalmol., Vol.46, p.927, 1958.

13. Duane: Arch. of Ophthalmol., Vol.51, No.3, 1954.

14. Zambert, E. and Wood, E.I.: Clinic. Medic. North America, Vol.30, pp.833 - 844, 1946.